RE-EVALUATION OF EARTHQUAKE POTENTIAL AND SOURCE IN THE VICINITY OF NEWBURYPORT, MASSACHUSETTS

Final Technical Report

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Abstract

During the first year of this paleoseismic study (USGS award 01HQGR0163), we found small, earthquake-induced liquefaction features and a distinctive sand layer, possibly a tsunami deposit, in Holocene marsh deposits near Hampton Falls, New Hampshire. During the second year of the study, presented here, we conducted additional reconnaissance for earthquake-related features and deposits as well as investigations at sites of liquefaction features and the possible tsunami deposit. Reconnaissance was performed along several rivers in southeastern New Hampshire, including the Blackwater and Browns Rivers and Hunts Island and Mill Creeks in Hampton Marsh and the Exeter and Squamscott Rivers northwest of Hampton Marsh. However, no new occurrences of liquefaction features or possible tsunami deposits were found. The site investigations included describing stratigraphic sections, geoslicing, augering, dating organic samples, and analyzing diatom assemblages. Preliminary analyses of stratigraphy and diatom assemblages suggest that deposition of the distinctive sand layer marks an abrupt change from a freshwater, grass-covered environment to a brackish-water, tidal-flat habitat consistent with rapid submergence and tsunami inundation. Radiocarbon dating of the liquefaction features and the possible tsunami deposit indicates that they formed about the same time, roughly 2,200 years ago. A broader search for liquefaction features and tsunami deposits along the central New England coast is warranted and may help to improve our understanding of the long-term earthquake potential of this region.

Introduction

Northeastern Massachusetts, southeastern New Hampshire, and southernmost Maine have experienced many small, and several moderate to large, earthquakes during the past 400 years (Figures 1 and 2). The two most notable earthquakes, the 1727, felt-area magnitude, **M**fa 5.5, Newburyport and 1755, **M**fa 6, Cape Ann events, induced liquefaction and caused damage to buildings (Ebel, 2000 and 2001). No doubt a repeat of these events would cause more damage today in this heavily developed and densely populated region. During a paleoseismology study conducted in the Newburyport area in the late 1980s, Tuttle and Seeber (1991) found both historic and prehistoric liquefaction features (Figure 2). The historic features were attributed to the 1727 earthquake and the prehistoric features were estimated to have formed during the past 4,000 years. Because the ages of the prehistoric liquefaction features were poorly constrained, the number and timing of paleoearthquakes were not estimated. In addition, the area over which the prehistoric earthquake(s) induced liquefaction was not determined, limiting interpretations of earthquake source and magnitude.

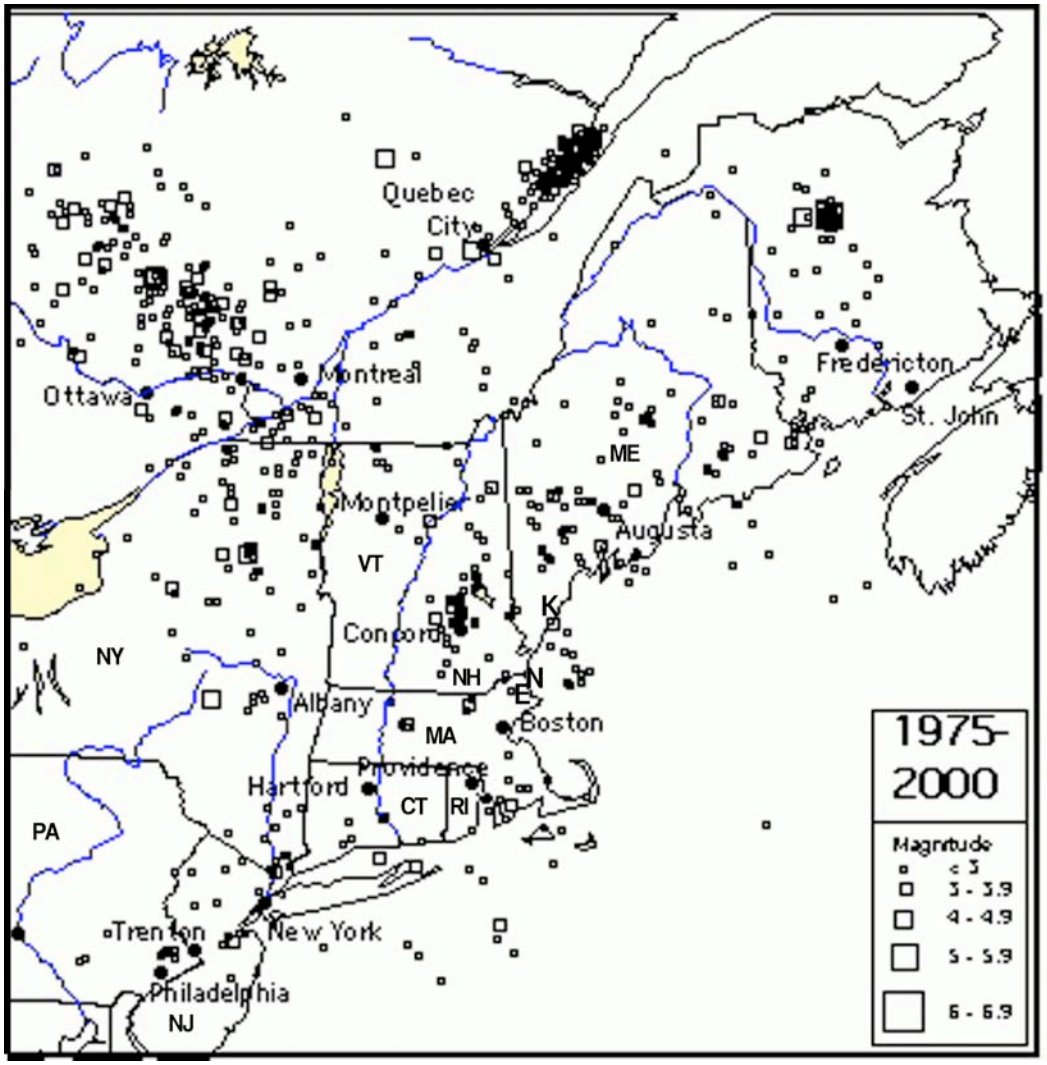

Figure 1. Map of northeastern U.S. showing seismicity from 1975 to 2000. Note north-northwest trend of seismicity off coasts of northeastern MA, southeastern NH, and southern ME. E, N, and K denote locations of Essex, Newburyport, and Kennebunk, respectively. Figure provided by J. Ebel.

During the first year of this project, the PI, Martitia Tuttle, in collaboration with John Ebel and Ed Myskowski of Boston College, compiled and reviewed bedrock geology data for the Newburyport area, conducted a geophysical survey and trenched promising targets near a site of historic liquefaction in Newburyport, and searched for liquefaction and other earthquake-related features along the Little River south of Newburyport and along the Tide Mill Creek and Hampton, Hampton Falls, and Taylor Rivers south of Hampton, New Hampshire (Figures 2 and 3). We selected these rivers for reconnaissance because accounts of vented sand and water in Newbury, Newburyport, Hampton, and Hampton Falls during the 1727 earthquake (Brown, 1990; Coffin, 1845) are indicative of earthquake-induced liquefaction. We have learned that sites of historic liquefaction, where liquefiable sediments occur, provide good targets for paleoliquefaction studies.

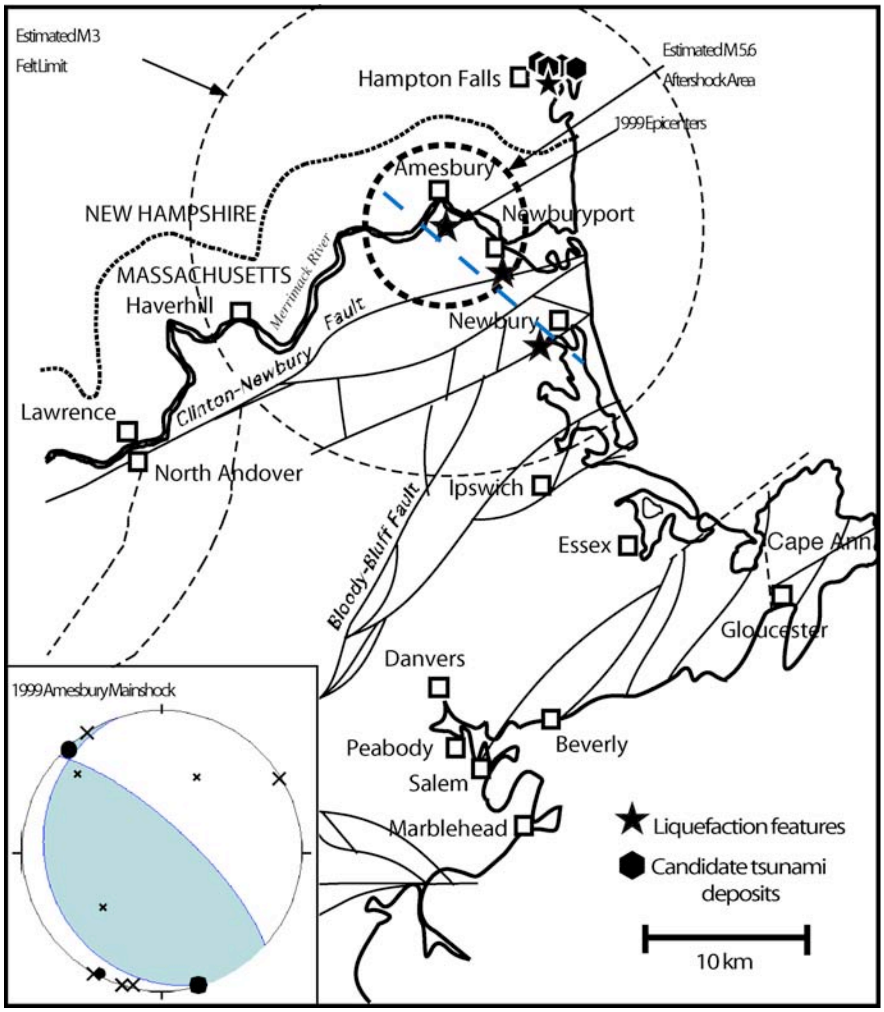

Figure 2. Map of the northeastern Massachusetts and southeastern New Hampshire (modified from Ebel, 2000) showing epicenter and aftershocks of 1999 Amesbury earthquake as well as its proposed source, a northwest-trending fault (blue dashed line), other mapped faults (light solid and dashed lines) from state bedrock map of Massachusetts (Zen et al., 1983), and locations of liquefaction features and candidate tsunami deposits (Tuttle and Seeber, 1991; and this report).

This paleoseismology project is a continuation of a pilot study begun in 2001 focusing on the Newburyport area (see report for NEHRP award 01HQGR0163). During that study, we compiled and reviewed bedrock geology data for the Newburyport area, conducted a geophysical survey and trenched promising targets near a site of historic liquefaction in Newburyport, and searched for liquefaction and other earthquake-related features along the Little River south of Newburyport and along the Tide Mill Creek and Hampton, Hampton Falls, and Taylor Rivers near Hampton Falls, New Hampshire (Figures 1, 2, and 3).

Figure 3. Orthophotoquad (modified from U.S. Geological Survey terraserver image) of Hampton Marsh showing locations of liquefaction features (L) and possible tsunami deposits (T). During this study, reconnaissance of similar features and deposits was carried out along portions of Blackwater and Browns Rivers and Hunt Island and Mill Creeks, but limited along two rivers by security perimeter (red bars). Geoslicing was performed at liquefaction site HR1, and diatom analysis was conducted on samples collected at TR1 and HR3.

We selected those rivers for reconnaissance because accounts of vented sand and water in Newbury, Newburyport, Hampton, and Hampton Falls during the 1727 earthquake (Brown, 1990; Coffin, 1845) are indicative of earthquake-induced liquefaction. During reconnaissance, we found a 3-cm-wide silty, very fine sand dike in marsh deposits along the Hampton Falls River. Unfortunately, the upper part of the sand dike had washed out of the cutbank. At the same site, a 3-cm thick layer of silty, very fine sand extends and pinches out away from the sand dike. Its similarity in grain-size suggests that the sand layer may be a related sand blow or sill.

Radiocarbon dating of organic material collected adjacent to the top of the intact portion of the sand dike (HR1- 3070-2860 B.P.) indicated that the liquefaction features formed less than 3,070 years ago. If the silty sand layer were a related sand blow or sill, it would help to better constrain the timing of the event.

During the same study, a distinctive sand layer was found at several locations from 1.5 to 4 km inland from the beach near the landward margin of Hampton Marsh (Figure 3). The sand layer is 2 to 4-cm thick, composed of grayish, massive silty, fine to very fine sand and contains angular lithic fragments. The sand layer occurs below marsh and tidal flat deposits and above a paleosol containing large *in situ* tree roots and other woody material. The underlying paleosol is developed in silty, very fine sand and contains a few, small subrounded pebbles and granules, but not angular rock fragments. Radiocarbon dating of a tree root at Taylor River site 1 (TR1- 3140 $\pm$ 70 years B.P.) indicated that the overlying sand layer was deposited less than 3,200 years ago.

From Portsmouth, NH to the head of the Bay of Fundy, tree stumps have been noted below marsh deposits. Burial of trees has been attributed to Holocene sea-level rise and downward crustal movement. Similarly, the buried trees at Hampton Marsh maybe related to sea-level rise. However, the literature of coastal Holocene stratigraphy for this part of New England rarely mentions the occurrence of sand between buried soil and marsh deposits. One exception is in Wells Marsh located in southeastern Maine (ME) and about 36 km north of Hampton Marsh. Here, a stratigraphic section near the landward margin of the marsh shows a sand layer above a basal peat deposit in which tree stumps are rooted (Hussey, 1970). These tree stumps are similar in age (2810 $\pm$ 200 yr B.P. and 2980 $\pm$ 180 yr B.P.; Hussey, 1959, 1970) to the one we dated at Hampton Marsh. The sand layers at Hampton and Wells Marshes were deposited in similar geomorphic positions and about the same time. For marshes northeast of Portland, ME, there is no similar sand layer described at the base of the Holocene section.

The Hampton Marsh sand layer resembles a tsunami deposit related to the 1929 Grand Banks earthquake that was documented at eight sites along 40 km of the southern coast of Newfoundland (Tuttle et al., 2004). At Taylor's Bay, the tsunami deposit ranges from a massive sand containing many lithic fragments to a fining upward, very coarse to fine-grained sand. At this site, the tsunami sand was deposited on a peat bog behind a tidal pond at an elevation 3 m above the top of the barrier beach. At other sites along the Newfoundland coast, the tsunami deposit overlies a paleosol containing tree stumps. Tree death was probably due to sediment burial or short-term, salt-water inundation.

If the distinctive sand layer at Hampton and Wells Marshes is a tsunami deposit, it would indicate a Late Holocene earthquake and/or subacqueous slide. A northwest-oriented trend of seismicity has been noted about 40 km off the coast of northeastern Massachusetts, southeastern New Hampshire, and southern Maine (Ebel, 2001). The 1755 Cape Ann earthquake probably occurred near the southern end of the trend. Therefore, the offshore seismicity may delineate an active fault and possible source of large earthquakes.

The goal of this study is to gather additional information about earthquake-related features and deposits that could improve estimates of timing, source areas, and magnitudes of prehistoric earthquake(s), and thus recurrence times of damaging earthquakes along the central New

England coast (Figure 1). Towards this end, the Principal Investigator, Martitia Tuttle, in collaboration with John Ebel of Boston College, and with the assistance of Jeremy Efros and Kathleen Dyer-Williams, conducted reconnaissance along additional rivers in Hampton Marsh and surrounding area. We collected geoslices at the liquefaction site in Hampton Marsh hoping to observe the upper termination of the sand dike and its relationship to the possible sand blow or sand sill. We described sedimentary sections of sites where the distinctive sand layers were found and collected samples for diatom analysis and radiocarbon dating. Andrzej Witkowski, a leading authority on diatom flora of the American coasts, performed diatom analysis and Beta Analytic, Inc. carried out radiocarbon dating for this study.

Investigations

Reconnaissance

We conducted reconnaissance for earthquake-related features and deposits along several rivers in southeastern New Hampshire (Figure 4). In Hampton Marsh, we surveyed 3.8 km of Blackwater River, 2.2 km of Browns Creek, 1 km of Hunt Island Creek, and 1.6 km of Mill Creek (Figure 5).

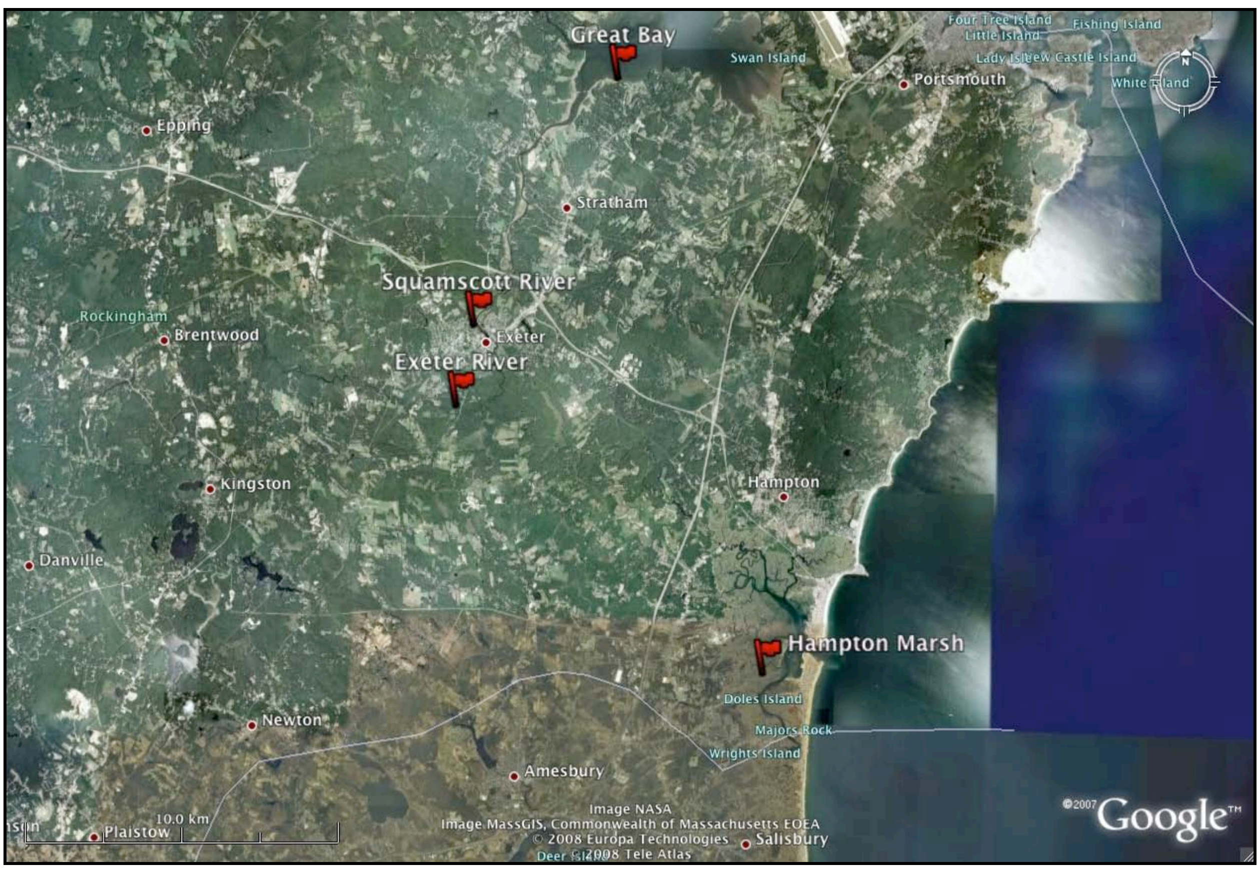

Figure 4. Google Earth image of southeastern New Hampshire showing locations of Hampton Marsh, and Exeter and Squamscott Rivers where reconnaissance was conducted.

Figure 5. Google Earth image of Hampton Marsh showing portions of Browns, Hunt Island, and Mill Creeks and Blackwater River that were surveyed for earthquake-related features and tsunami deposits.

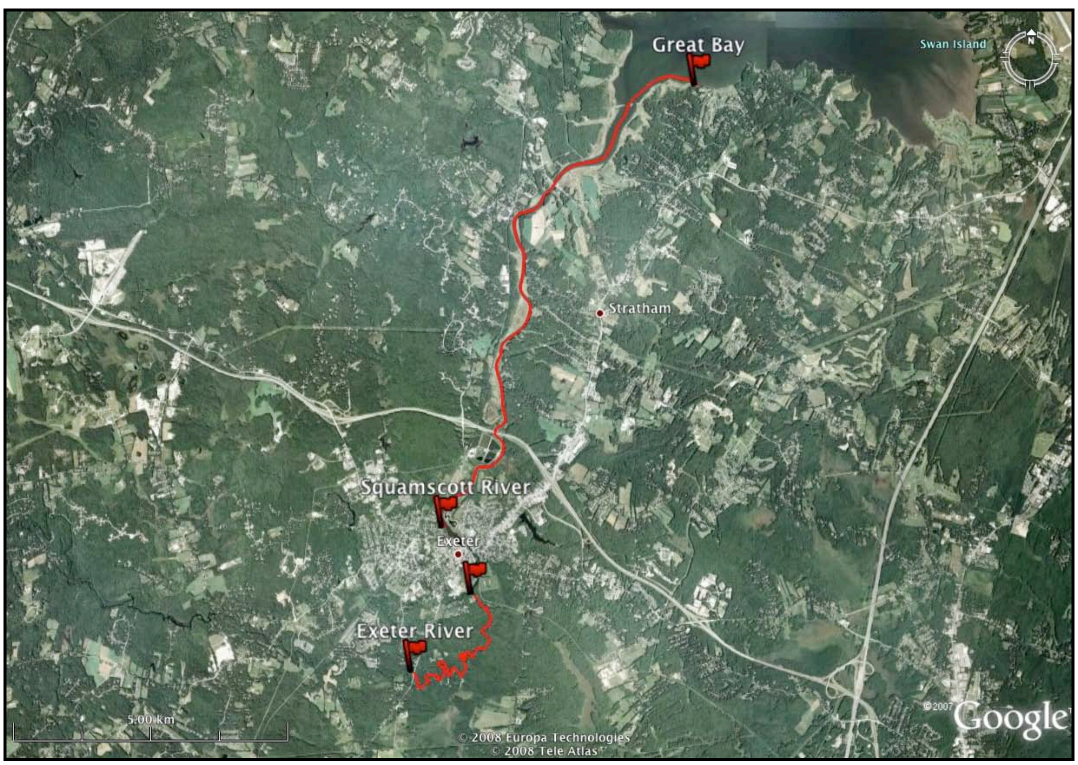

Figure 6. Google Earth image showing portions of Exeter and Squamscott Rivers south of Great Bay that were surveyed for earthquake-induced liquefaction features.

Surveys along Browns Creek and Hunt Island Creek were limited by the security perimeter around Seabrook nuclear power plant. Northwest of Hampton Marsh, we surveyed 5 km of the Exeter River and 11 km of the Squamscott River (Figure 6). Exposure was good to excellent at low tide along rivers in Hampton Marsh, but only poor along the Exeter and Squamscott Rivers. Marsh, marine silt and clay, and marine sand deposits are mapped along the rivers in both areas (Delcore and Koteff, 1989; and Koteff, 1991). We requested and received from the New Hampshire Department of Transportation, borehole data from bridge crossings of several of the rivers in the study area including the Taylor River, Tide Mill Creek, Exeter River, and Squamscott River. The borehole data suggest that there is little if any sediment likely to be susceptible to liquefaction at the Taylor River or Tide Mill Creek crossings. The borehole data for the Exeter and Squamscott Rivers, on the other hand, suggest that liquefiable sediments are present at these locations.

We found no additional earthquake-related features or possible tsunami deposits along any of the rivers surveyed during this study. However, this may be due to poor exposure along the Exeter and Squamscott Rivers, inability to access the landward margin of the marsh due to the security perimeter around Seabrook nuclear power plant, and scarcity of liquefiable sediments for portions of Hampton Marsh.

Liquefaction Site

The liquefaction site at HR1 in Hampton Marsh was revisited, and the sand dike and its host deposits reexamined (Figure 3). As before, the upper portion of the sand dike had been eroded and the relation between the sand dike and sand layer of similar grain-size, postulated to be a related sand blow or sand sill, was difficult to ascertain. An additional organic sample was collected adjacent to the uppermost intact portion of the sand dike and 7 cm below the sand layer and submitted for radiocarbon dating. The sample (HR1-O2) yielded a 2 sigma calibrated age of 2750-2680, 2660-2480 B.P., indicating that the sand dike is at least 100-600 years younger than previously estimated.

Because the sediment above the sand dike was eroded ~1.5 m into the bank, we collected geoslices of the sedimentary section 1.6 m inland in an attempt to sample the upper portion of the sand dike. We wanted to determine the maximum height of the sand dike to observe its relation with the sand layer of similar grain-size and to further constrain its age. With the geoslicer, we cut five contiguous sections (1 m deep, 15 cm wide, and 4 cm thick) along a line perpendicular to the strike of the sand dike (see Figures 7 and 8). We cut a sixth slice below the section and on strike with the sand dike exposed in the lower portion of the bank. Unfortunately, the sand dike was not intersected by any of the geoslices. We conclude that the sand dike did not extend this far into the bank and that the entire length of the sand dike had been washed out by tidal and wave action. Using a Dutch Spoon, we sampled sediments below the geosliced section and found light brown silty, very fine sand from 2.45-2.6 m below the surface. This sediment is similar in color and grain-size to the sand dike and in the likely source of the sand that liquefied.

Figure 7. Geoslicer and related equipment. Sediments in tray on left recovered at liquefaction site along Hampton Falls River.

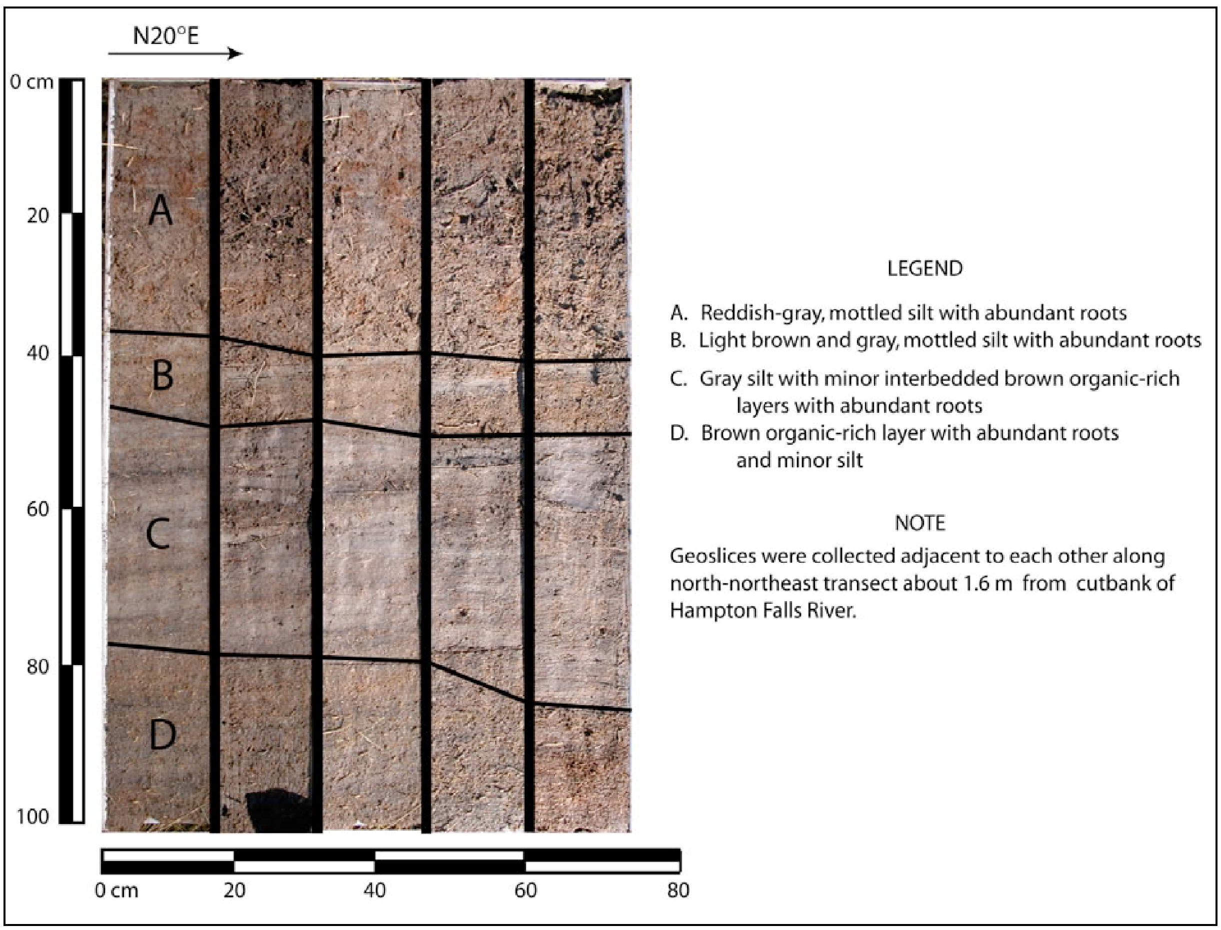

Figure 8. Five contiguous geoslices recovered along section perpendicular to strike of sand dike. Sixth geoslice was collected 1-2 m below surface.

Possible Tsunami Deposit

Several sites were revisited in Hampton Marsh where the distinctive sand layer had been found (Figure 9). The sediment profiles were described and samples collected for radiocarbon dating and diatom analysis. The profiles and results of radiocarbon dating are shown in Figure 10 and the results of diatom analysis are shown in Figures 11 and 12.

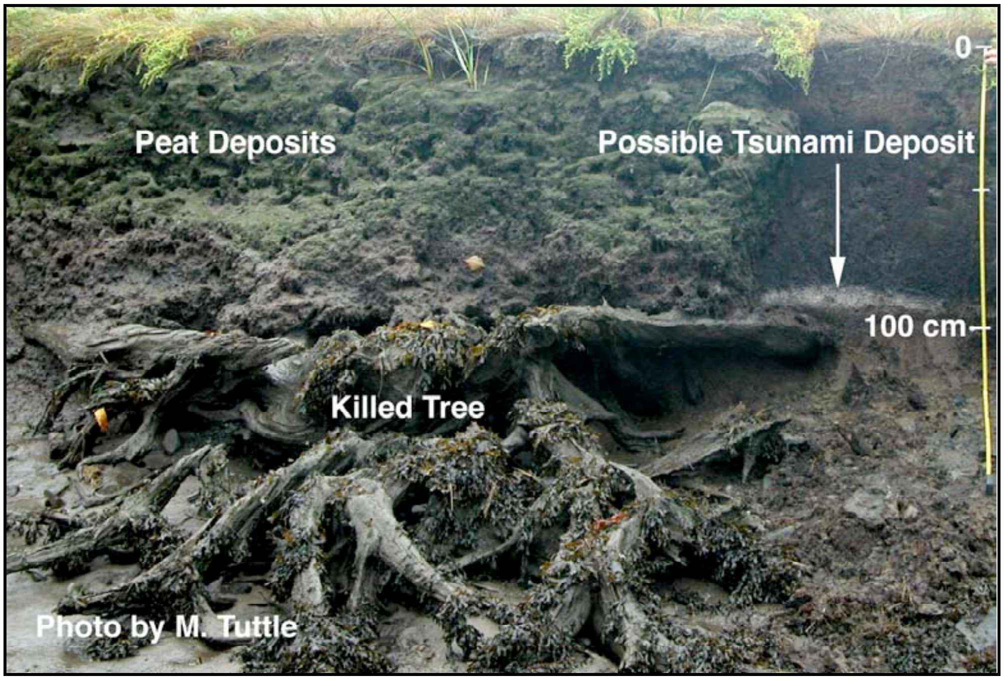

Figure 9. Distinctive sand layer overlying paleosol and stump of killed tree at HR3. Radiocarbon dating of plant fragments from soil sample (HR3-S5) immediately below sand deposit provides close maximum age estimate of 2370-2300 and 2250-2170 B.P.

The distinctive sand layer at Hampton Marsh is massive or composed of a few depositional units, some of which fine upward, and overlies a paleosol containing tree stumps and other woody material. It occurs near the back edge of the marsh. The Hampton Marsh sand layer resembles tsunami deposits along the southern coast of Newfoundland that resulted from the 1929 Grand Banks earthquake and submarine slumps (Tuttle et al., 2004). It does not resemble storm overwash deposits that often exhibit crossbedding and typically occur on the landward side of barrier beaches and extending short distances over adjacent marsh deposits and into tidal ponds.

Organic-rich samples were collected above and below the possible tsunami deposit for the purpose of radiocarbon dating (see Table 1 and Figure 10). The results of radiocarbon dating suggest that the distinctive sand was probably deposited between 2370-1990 B.P. A sample of organic-rich sediment (TR1-O1) collected immediately above the sand deposit yielded a 2-sigma calibrated age of 2300-2260 and 2160-1990 B.P. and provides minimum age constraint for the possible tsunami deposit. Plant fragments sieved from a 1-cm thick sample (HR3-S5) collected immediately below the sand layer provides close maximum age constraint of 2370-2300 and 2250-2170 B.P. In addition, three samples (HR3-W2, TM1-W1, TR4-W1) collected from *in situ* tree trunks or roots in soil below the sand layer and a sample from a horizontally bedded tree trunk (TM3-W1) in the top of the sand layer provide additional maximum age constraint consistent with that of the plant fragments.

Table 1. Hampton Marsh Radiocarbon Dating Results.

Sample # Lab #	$^{13}C/^{12}C$ Ratio	Radiocarbon Age Yr B.P.[1]	Calibrated Radiocarbon Age Yr B.P.[2]	Calibrated Calendar Date A.D./B.C.[2]	Sample Description
HR1-O2 Beta-169802	-12.6	2540 ± 40	2750-2690 2660-2480	800-740 B.C. 710-530 B.C.	Organic sediment collected 18 cm below possible sill and just above dike tip
HR3-S5 Beta-204198	-19.8	2310 ± 50	2370-2300 2250-2170	420-350 B.C. 300-220 B.C.	Plant fragments from 1-cm-thick soil sample immediately below possible tsunami deposit
HR3-W2 Beta-183860	-27.3	3280 ± 50	3630-3390	1680-1440 B.C.	Outer few cm *in situ* tree stump buried by possible tsunami deposit
TM1-W1 Beta-169803	-29.1	2310 ± 80	2700-2650 2490-2140	750-700 B.C. 540-190 B.C.	Outer few cm *in situ* tree root below possible tsunami deposit
TM3-W1 183861	25.4	3010 ± 60	3360-2990	1410-1040 B.C.	Outer few cm of horizontal tree trunk in top of possible tsunami deposit
TR1-O1 Beta-169804	-24.7	2120 ± 40	2300-2260 2160-1990	350-310 B.C. 210-40 B.C.	Organic sediment 0-1 cm above possible tsunami deposit
TR4-W1 Beta-169805	-28.3	2050 ± 70	2290-2270 2160-1860	340-320 B.C. 210-90 B.C.	Outer 1 cm *in situ* tree root at base of possible tsunami deposit

[1] Conventional radiocarbon ages in years B.P. or before present (1950) determined by Beta Analytic, Inc. Errors represent 1 standard deviation statistics or 68% probability.

[2] Calibrated age ranges as determined by Beta Analytic, Inc., using the Pretoria procedure (Talma and Vogel, 1993; Vogel et al., 1993). Ranges represent 2 standard deviation statistics or 95% probability.

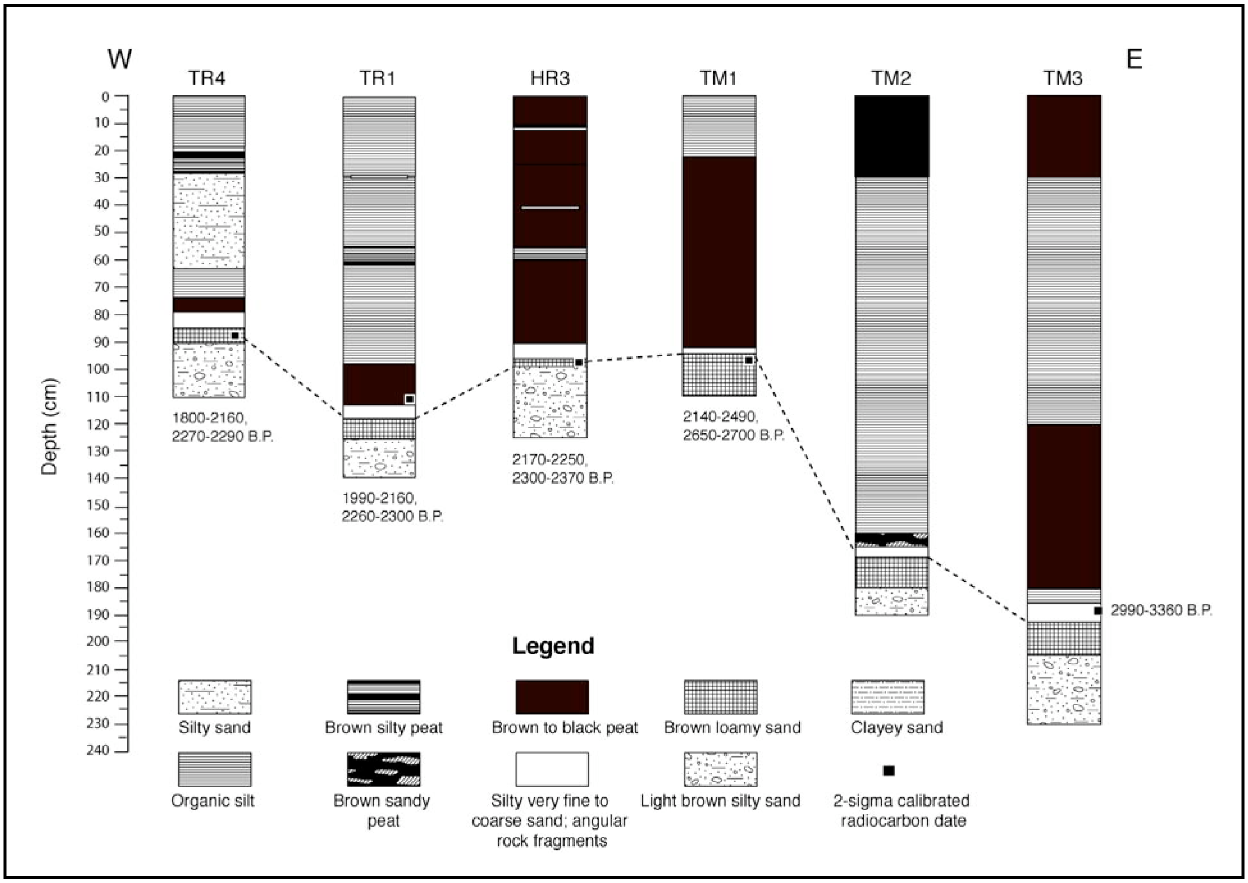

Figure 10. Stratigraphic sections and radiocarbon dates for sites at Hampton Marsh. See Figure 3 for locations of sites TR4, TR1, HR3, TM1, TM2, and TM3. Radiocarbon dating suggests that sand layer was deposited about 2,200 years ago.

At Taylor River 1 (TR1) and Hampton Falls River 3 (HR3), we collected samples for diatom analysis. The samples were 1 cm-thick and 10 cm-square and cut at 10 cm intervals from a vertical profile. Andrzej Witkowski and Genowefa Daniszewska-Kowalczyk performed diatom taxonomic identification (Patrick and Reimer, 1966; Witkowski et al., 2000). Sediment samples of 1.0-1.5 g were treated with 10% HCl to remove calcium carbonate, washed several times with distilled water, boiled in concentrated H_2O_2 to oxidize all organic matter, and washed several more times with distilled water. From the sample residue, a defined aliquot was taken from the homogenized suspension, placed on cover glasses and left to dry. Permanent diatom preparations were mounted in Naphrax. Diatom identification was performed using a Leica DM LB microscope with x100 Planapo optics (bright field) and oil immersion. The results of the analyses are shown in Figures 12 and 13 and examples of diatoms and phytolites are shown in Figure 13.

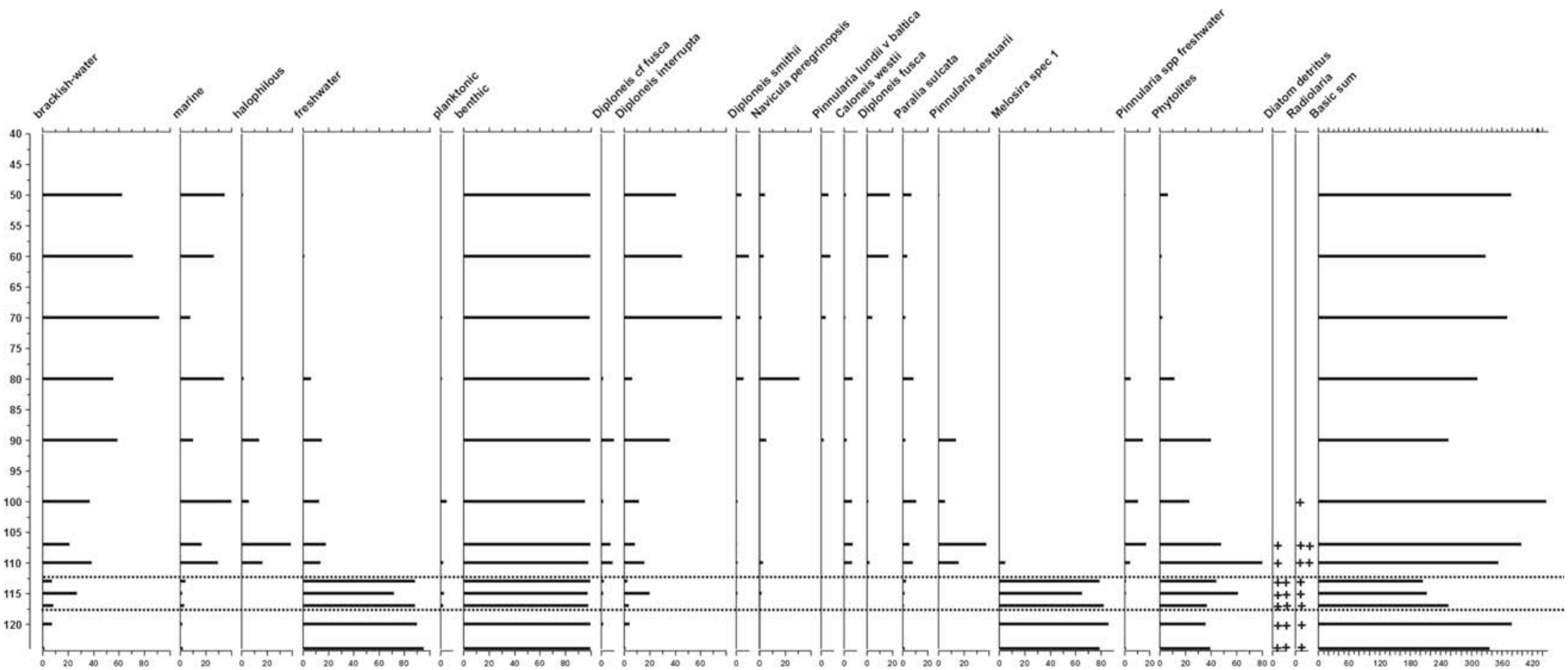

Figure 11. Diagram showing results of diatom analysis of samples collected at Taylor River site TR1. Depth (cm) below surface indicated on vertical axis; diatom type shown on upper horizontal axis and valve count shown on lower horizontal axis. Position of sand layer marked by dashed lines.

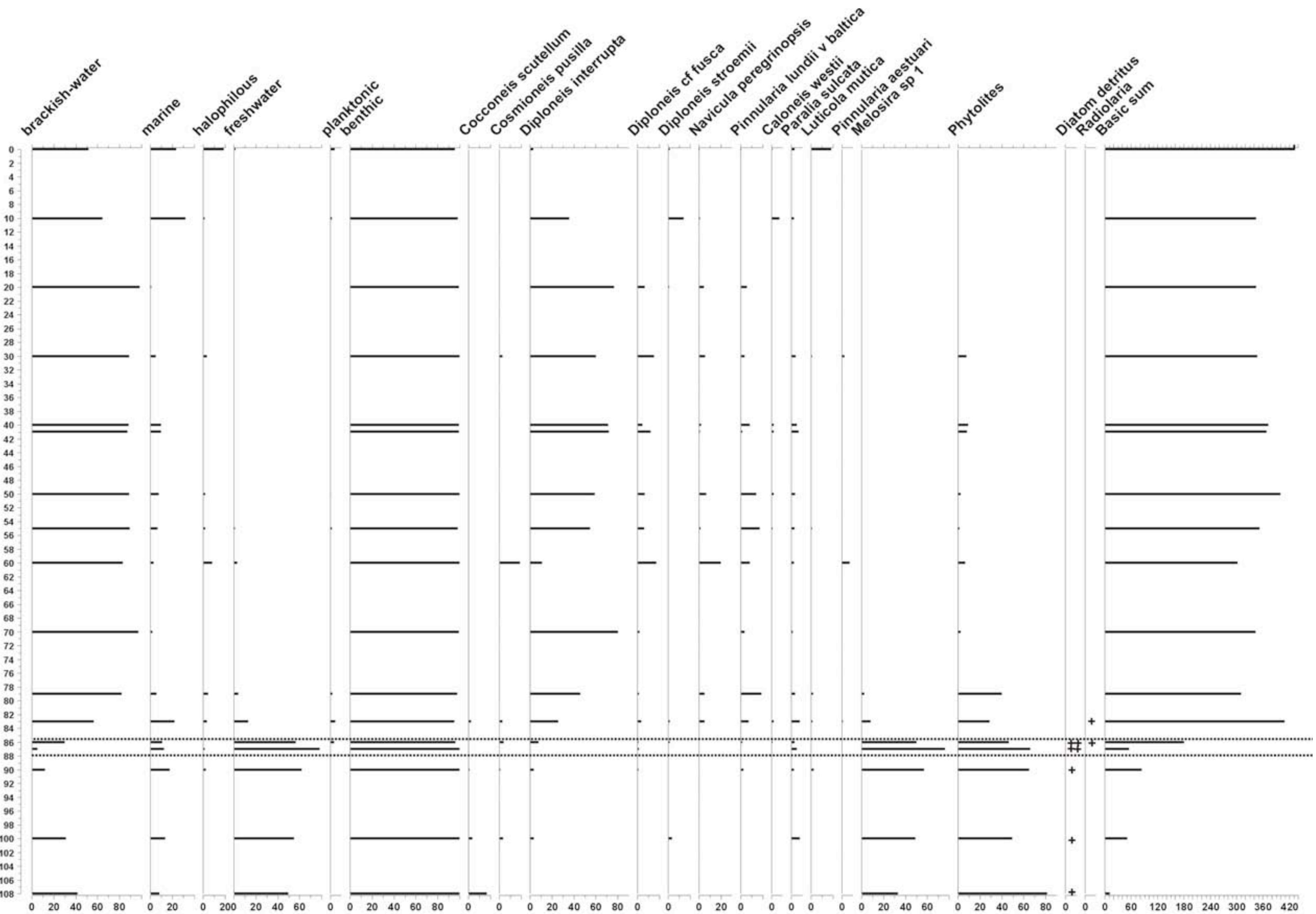

Figure 12. Diagram showing results of diatom analysis of samples collected at Hampton Falls River site HR3. Depth (cm) below surface indicated on vertical axis; diatom type shown on upper horizontal axis and valve count shown on lower horizontal axis. Position of sand layer marked by dashed lines.

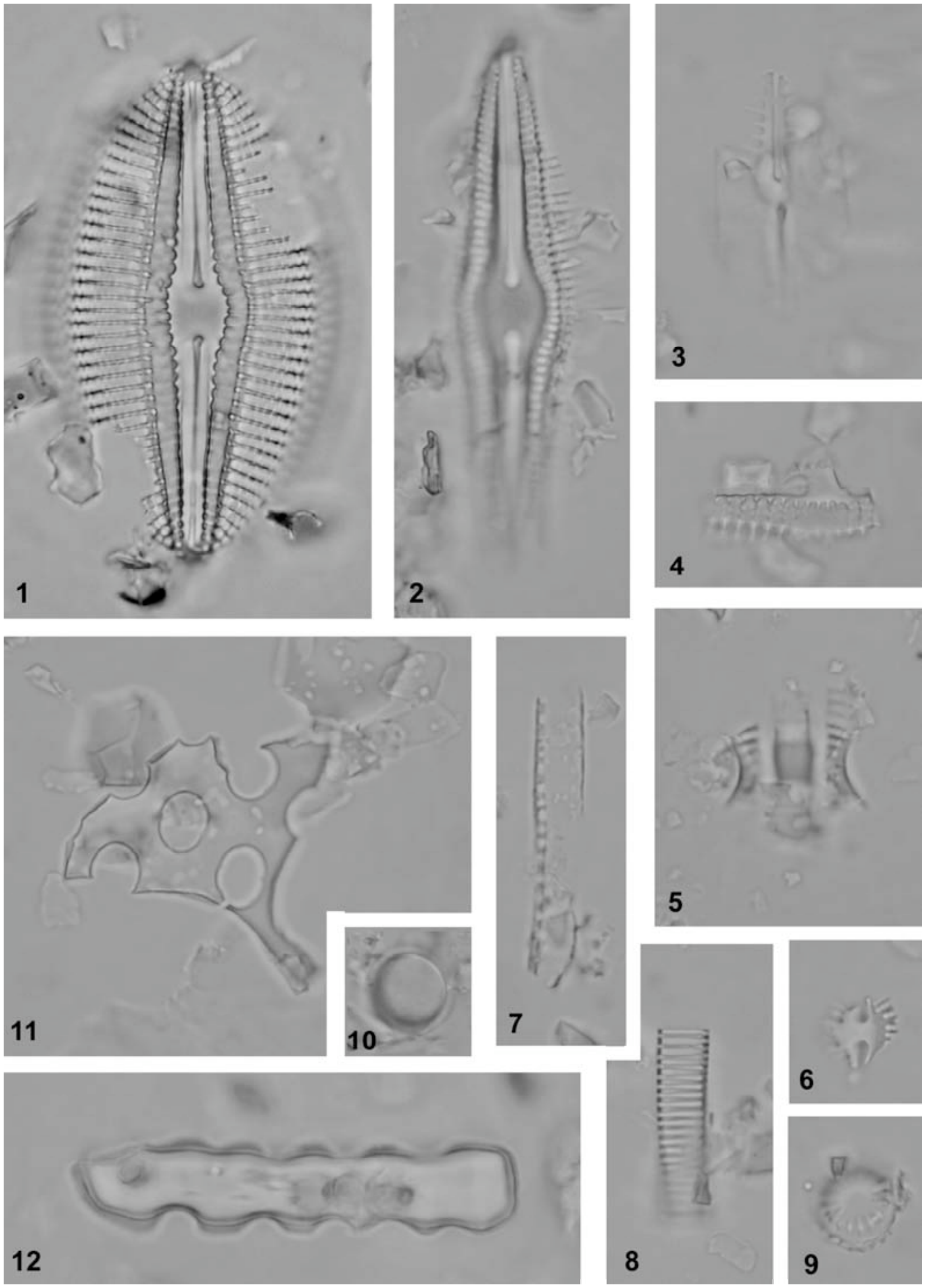

Figure 13. Microscopic plates showing fragmented diatom and phytoliths from sand layer at 86-87 cm depth at site HR3; Plates 1-3, 5-7 - brackish-water forms; Plates 4, 9, 11 - marine forms; Plates 8 and 10 - freshwater forms; Plate 10 - soil diatom. Plate 1. Diploneis smithii; Plate 2. Diploneis spec. 1; Plate 3. Pinnularia lundii var. baltica; Plate 4. Diploneis spec.; Plate 5. Diploneis interrrupta; Plate 6. Cosmioneis pusilla; Plate 7. Nitzschia clausii; Plate 8. Eunotia spec.; Plate 9. Paralia sulcata; Plate 10. Melosira spec. 1. (Martitia tuttleae); Plate 11. Isthmia spec.; Plate 12. Phytolith.

For TR1, the profile can be divided into three sections on the basis of species composition and proportions of particular taxa (Figure 11). The lowermost section (101-124 cm), in which the sand layer occurs, contains few marine and brackish-water diatoms and many more fresh-water diatoms including *P. sulcata*, *D. interrupta*, and *Melosira sp*., respectively. The underlying paleosol contains mostly freshwater diatoms such as *L. mutica*, *Melosira sp*., and *P. borealis*, typical of exposed wet soil. Phytolites, derived from higher plants, are abundant in both paleosol and possible tsunami deposit. The middle section (80-101 cm) contains diatom flora characterized by changing ratios between marine and brackish-water taxa with significant admixture of freshwater and halophilous taxa. In this section, *P. sulcata* and *N. peregrinopsis* are dominant. There is a high content of the freshwater diatom *Pinnularia sp*., possibly redeposited here. Radiolaria, which are marine planktonic forms, occur towards the base of the middle section. In the upper section (50-80 cm), brackish-water taxa, particularly *D. interrupta*, dominate.

For HR3, the profile also showed a distinct tripartition with respect to the species composition of the diatom flora (Figure 12). The lowermost section (88-108 cm) occurs immediately below the sand layer and is either completely barren or contains only a few diatom species with very low frequency including *Diploneis interrupta*, *Pinnularia lundii* v. *baltica*, *Cosmioneis pusilla*, *Paralia sulcata* and *Cocconeis scutellum*. These are marine and brackish-water species apparently brought in by airborne algae probably transported during strong storms. Freshwater, benthic species were dominant particularly *Melosira* spec. 1, and phytolites were abundant. *Melosira* spec. 1 represents soil diatoms and together with abundant phytolites are indicative of a paleosol. The middle section (86-88 cm), which is the sand layer itself, contains many fragmented diatoms (Figure 13) and a very high number or taxa, suggesting turbulent transport across several habitats including subtidal, intertidal, salt marsh, and paleosol. The upper section (0-86 cm) is marked by a decrease in phytolites upsection and is rich in species and abundance of diatoms. The dominant species are *Caloneis westii*, *Paralia sulcata* (marine), *Diploneis interrupta*, *D.* cf. *fusca*, *D. stroemii*, *Pinnularia lundii* v. *baltica*, *N. peregrinopsis* (brackish-water), *Luticola mutica* and *Pinnularia aestuarii* (halophilous or freshwater form but tolerate of some salt admixture). The most abundant diatom was the brackish-water species *Diploneis interrupta*.

Like the 1929 Grand Banks tsunami deposit in Newfoundland, the sand layer at TR1 and HR3 contains a mixture of marine, brackish-water, and fresh-water diatoms and a high concentration of diatom detritus or broken values, radiolaria , and phytolites, suggestive of landward transport of sediment across several habitats. Several species of diatoms found in the sand layer, including *Paralia sulcata, Diploneis smithii, and Cocconeis scutellum*, also occurred in the 1929 Newfoundland tsunami deposit and the Storegga tsunami deposit in Caithness, Scotland (Tuttle et al., 2004; Dawson et al., 1996).

The diatom flora of the lower sections of the profiles indicates instability of environmental conditions. Diatoms in the sediment above the sand layer suggest an initial stage of the tidal flat formation; whereas, diatoms even higher in the section suggest salt marsh formation. In the upper section, the diatom assemblage represents a well-established salt marsh habitat. It is remarkable that few transitional forms occur near the contact between the tidal flat and salt marsh deposits. In general, the diatom analysis indicates an abrupt change from freshwater, grass-covered environment to brackish water, tidal flat habitat about the time the sand layer was deposited. The abrupt change in depositional environment is consistent with rapid submergence and possibly tsunami inundation.

Conclusions

Reconnaissance for earthquake-related features and deposits was conducted in the southeastern New Hampshire in the area where liquefaction features and a possible tsunami deposit had been found during a previous pilot study. Surveys were performed along the Blackwater and Browns Rivers and Hunts Island and Mill Creeks in Hampton Marsh and the Exeter and Squamscott Rivers northwest of Hampton Marsh. No new occurrences of liquefaction features or possible tsunami deposits were found along any of these watercourses. In addition, investigations were conducted at sites where liquefaction features and a possible tsunami deposit had previously been found. The investigations included describing stratigraphic sections, geoslicing, augering, dating organic samples, and analyzing diatom assemblages. Preliminary analyses of stratigraphy and diatom assemblages suggest that deposition of the distinctive sand layer marks an abrupt change from a freshwater, grass-covered environment to a brackish-water, tidal-flat habitat consistent with rapid submergence and tsunami inundation. Radiocarbon dating of the liquefaction features indicates that they formed after 2750-2680, 2660-2480 B.P.; whereas, dating of the distinctive sand layer indicates that it was deposited between 2370-1990 B.P. It is possible, but not required, that the liquefaction features and possible tsunami deposit formed about the same time, roughly 2,200 years ago. A broader search for liquefaction features and tsunami deposits along the central New England coast is warranted and may help to improve our understanding of the long-term earthquake potential of this region.

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Non-technical Summary

Reconnaissance for earthquake-related features and deposits was conducted in the southeastern New Hampshire in the area where liquefaction features and a possible tsunami deposit had been found during a previous pilot study. No new occurrences of liquefaction features or possible tsunami deposits were found along any of the watercourses searched. Preliminary analyses of the possible tsunami deposit suggest that it marks an abrupt change in depositional environment consistent with rapid submergence and tsunami inundation. Radiocarbon dating of the deposit and liquefaction features suggests that they formed about the same time ~2.2 ka. A broader search for liquefaction features and tsunami deposits along the central New England coast seems warranted and might help to improve the understanding of the earthquake potential of the region.

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